(12) UK Patent Application (19) GB (11) 2 175 725 A

(43) Application published 3 Dec 1986

(21) Application No 8608121

(22) Date of filing 3 Apr 1986

(30) Priority data
(31) 60/071621 (32) 4 Apr 1985 (33) JP
60/258152 18 Nov 1985

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(51) INT CL[4]
G09G 3/00

(52) Domestic classification (Edition H):
G5C A310 A342 A365 HB

(56) Documents cited
GB A 2141279 GB A 2103003 GB 1401322
GB A 2139795 GB A 2075738 EP A2 0106386
GB A 2117157 GB 1468277

(58) Field of search
G5C
Selected US specifications from IPC sub-class G09G

(54) Improvements in or relating to electro-optical display devices

(57) The invention relates to methods for driving an electro-optical display device including an electro-optical modulation element e.g. a ferro-electric liquid crystal having different response conditions to direction of an applied field. Pulse groups P_1 or P_2 are applied at the display elements, on a time sharing basis. The voltage difference between a desired signal and a selection signal is such as not to permit, after the application of a display control pulse, the response condition to be changed by a following pulse. Said pulse groups P_1,P_2 includes pulses of different polarities but similar in number and waveform and the response condition is maintained by AC pulses A_1,A_2 when such pulse group is not applied.

FIG.2

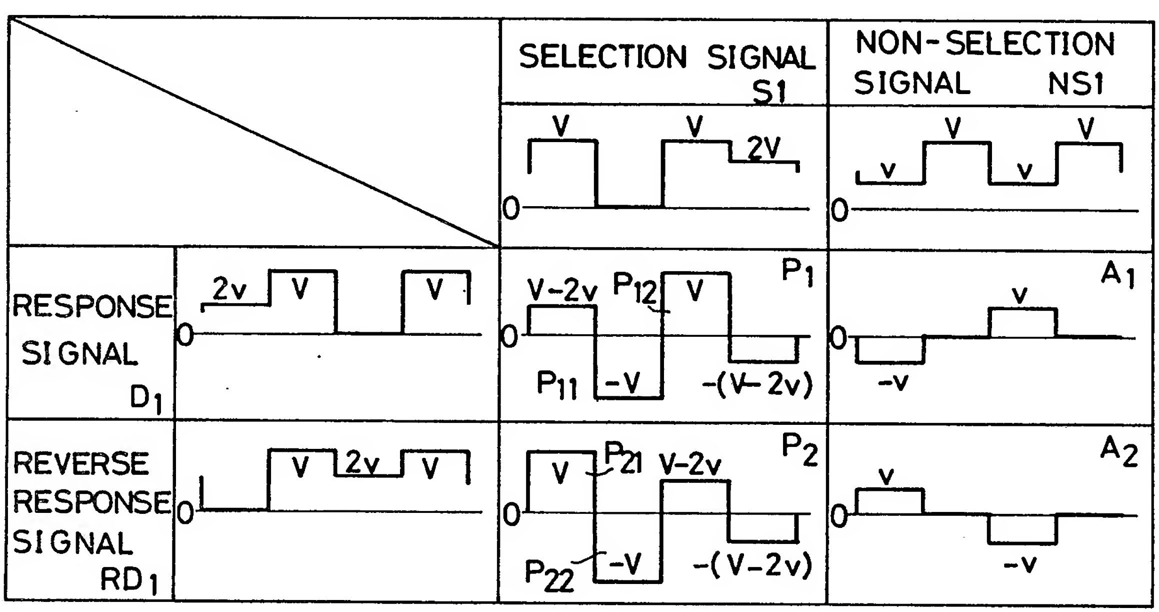

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FIG.1

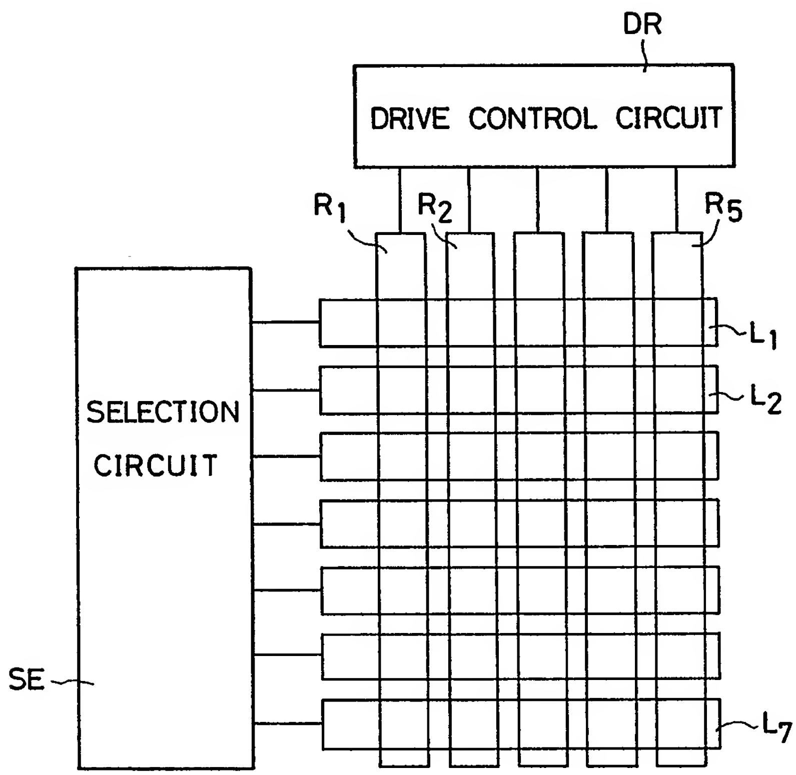
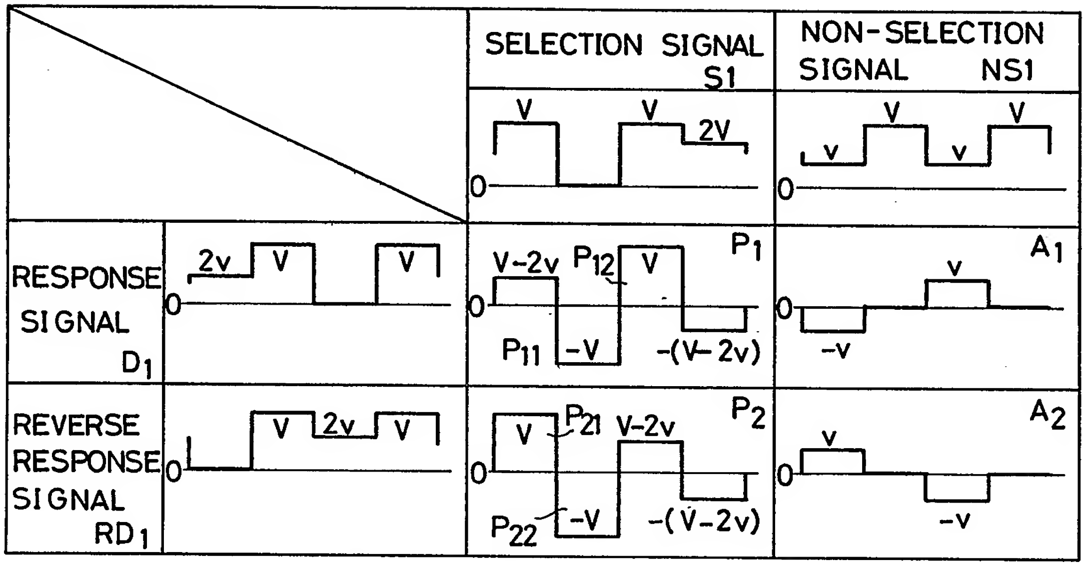

DR
DRIVE CONTROL CIRCUIT
R1
R2
R5
L1
L2
L7
SELECTION
CIRCUIT
SE

FIG.2



V=10V

FIG.3

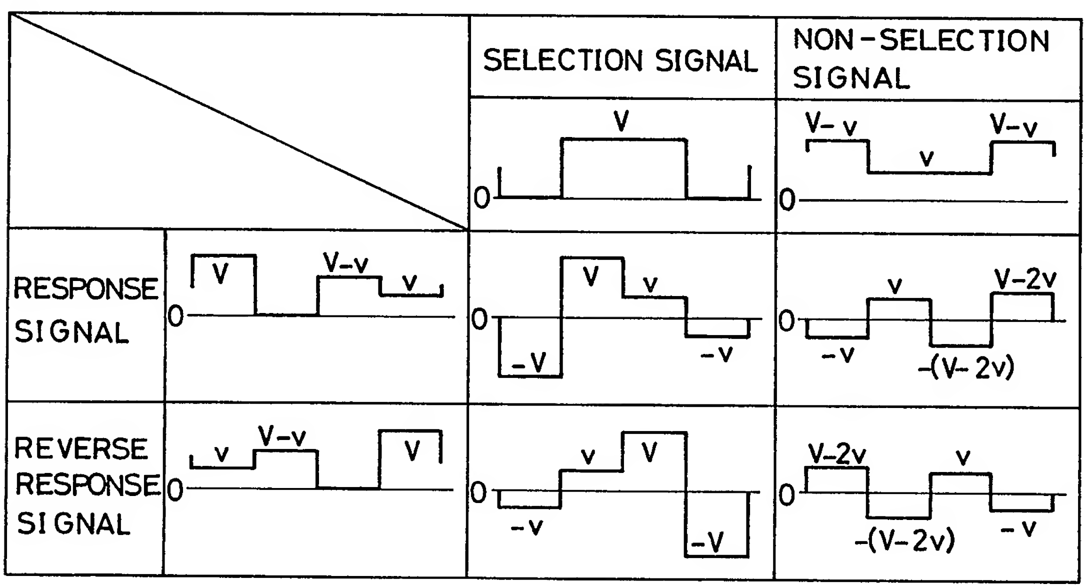


FIG.4

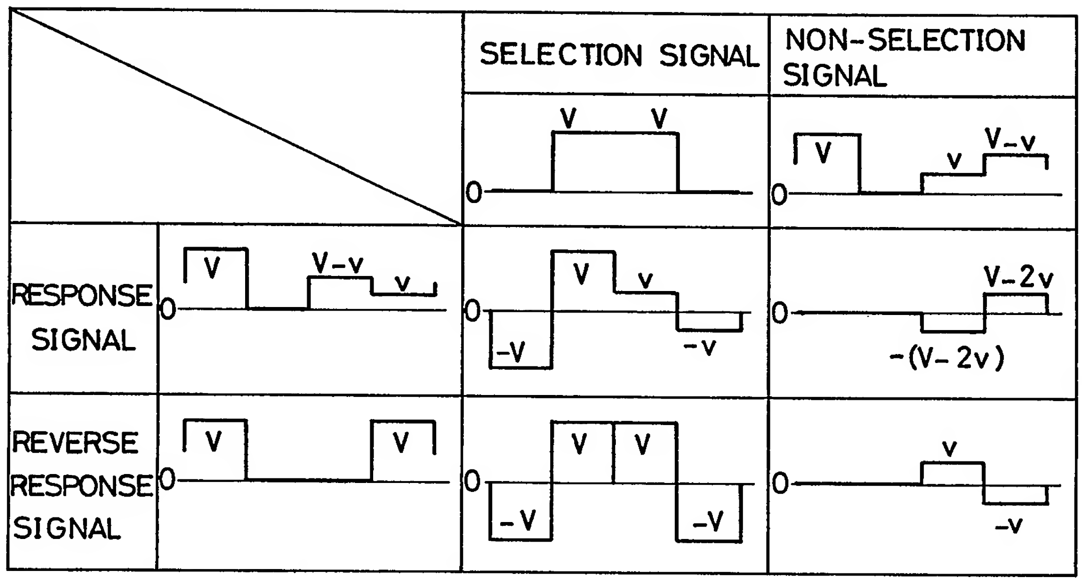

SELECTION SIGNAL
NON-SELECTION SIGNAL
RESPONSE SIGNAL
REVERSE RESPONSE SIGNAL
V
V-v
v
-V
-v
V-2v
-(V-2v)
0

FIG.5

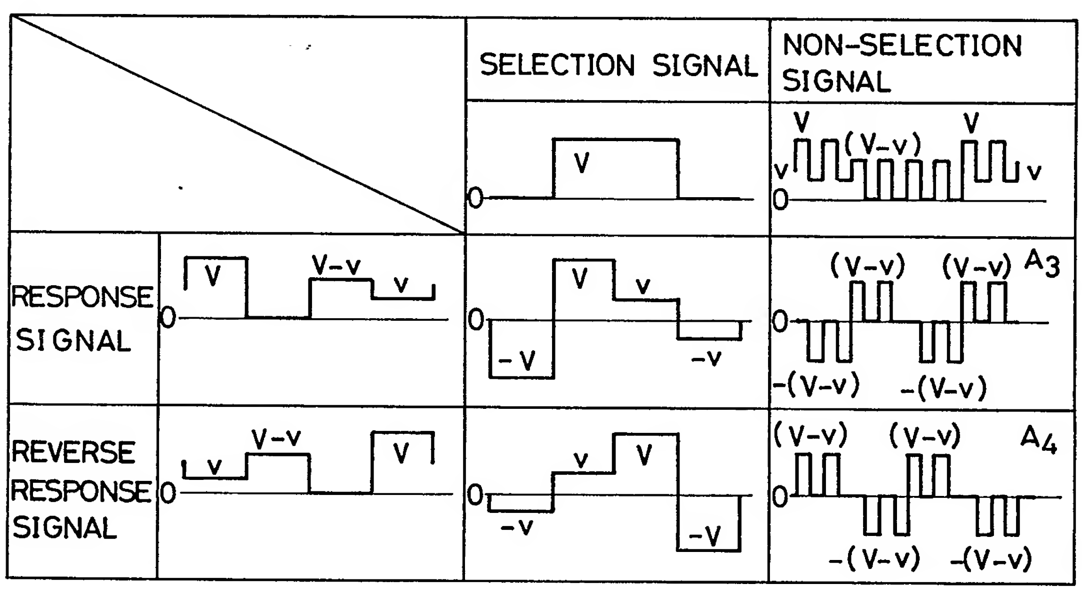

SELECTION SIGNAL
NON-SELECTION SIGNAL
RESPONSE SIGNAL
REVERSE RESPONSE SIGNAL
V
v
(V-v)
V-v
-V
-v
-(V-v)
A3
A4
0

FIG.6

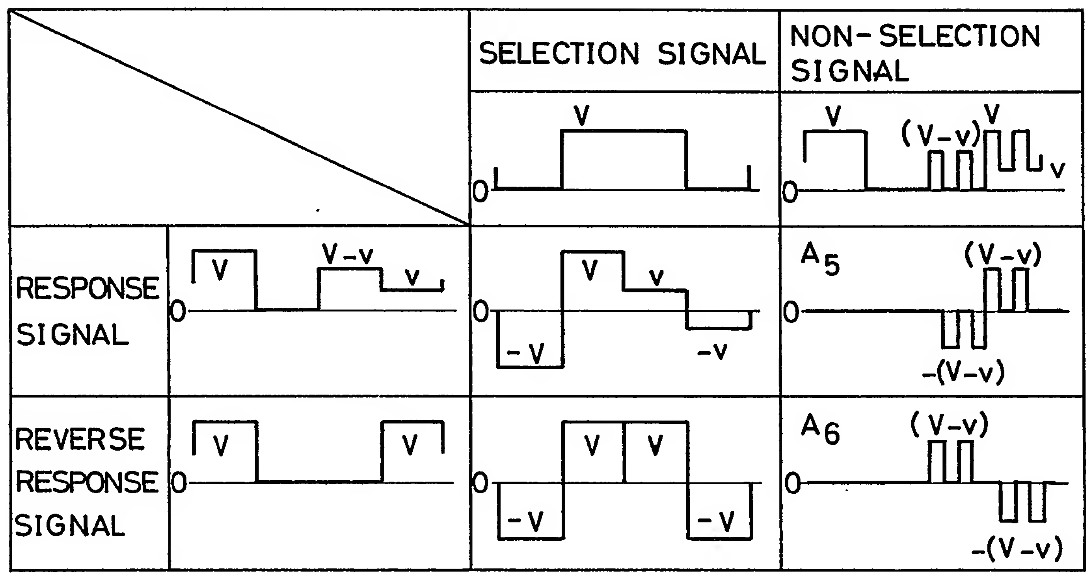

SELECTION SIGNAL
NON-SELECTION SIGNAL
RESPONSE SIGNAL
REVERSE RESPONSE SIGNAL
V
0
(V-v)
v
V-v
-V
-v
A5
-(V-v)
A6

FIG.7

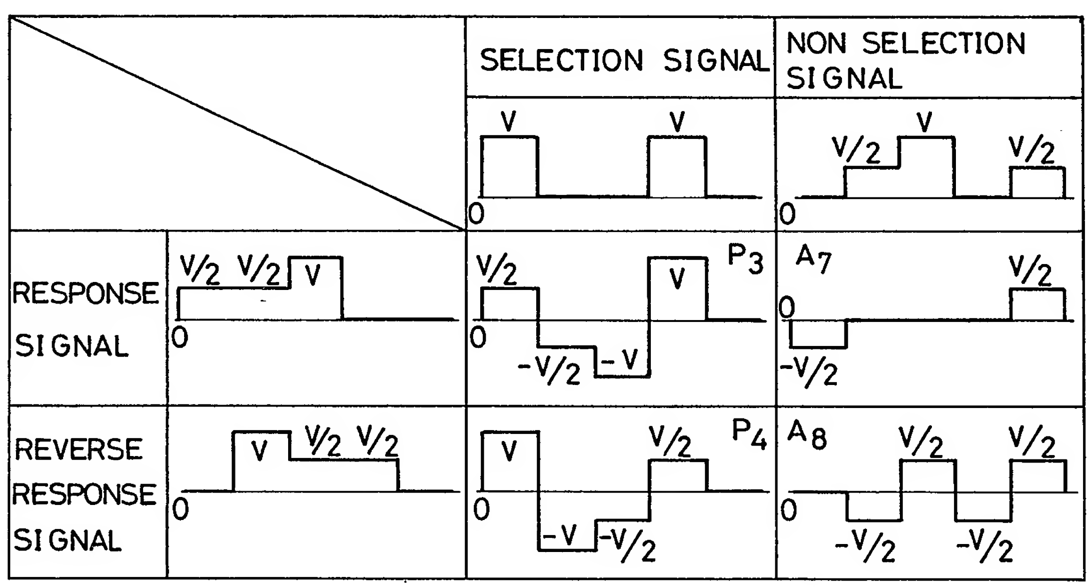

SELECTION SIGNAL
NON SELECTION SIGNAL
RESPONSE SIGNAL
REVERSE RESPONSE SIGNAL
V
V/2
0
-V/2
-V
P3
P4
A7
A8

FIG.8

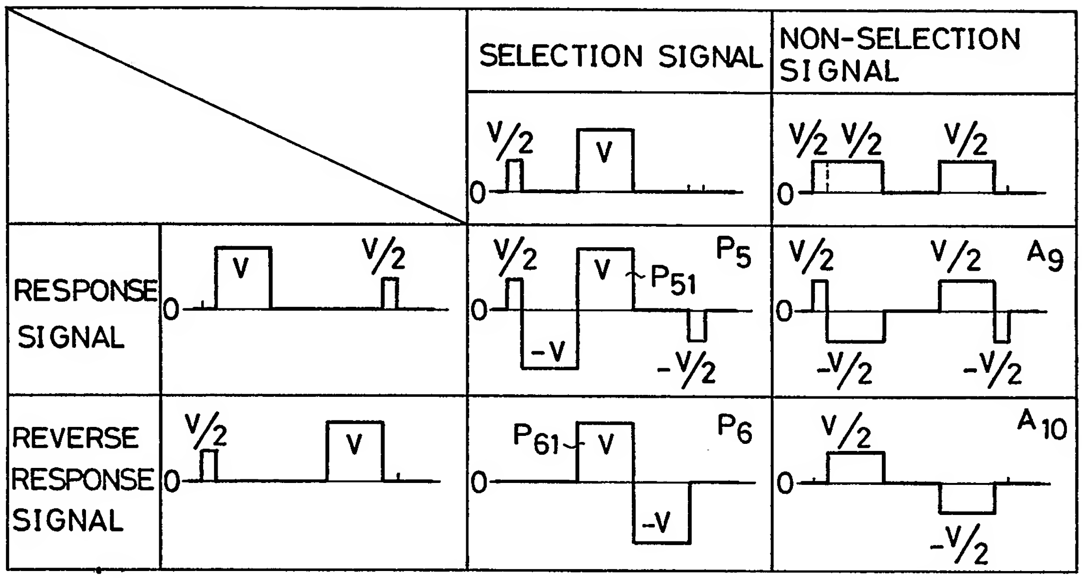
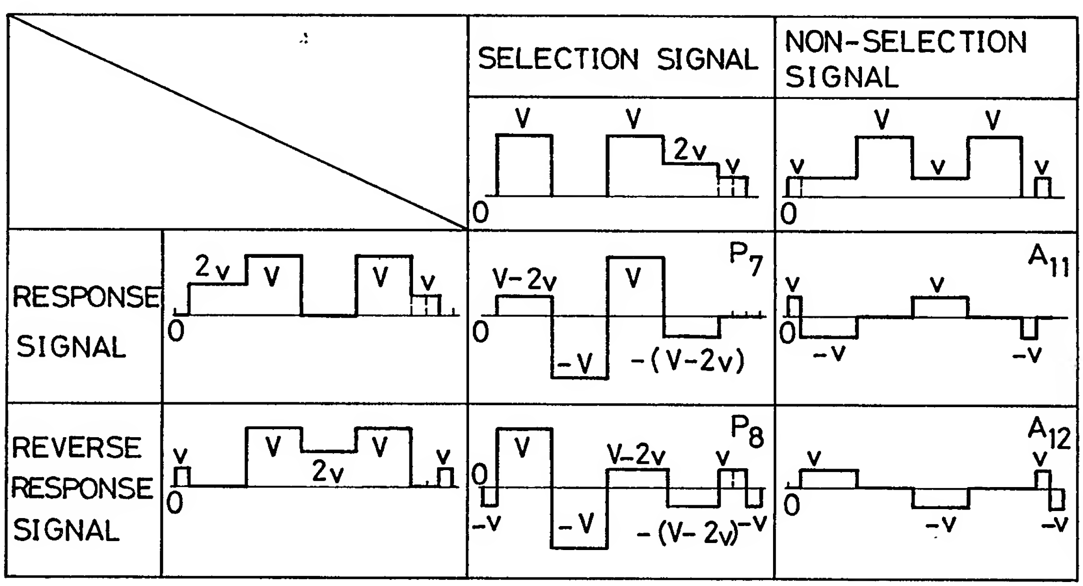

SELECTION SIGNAL
NON-SELECTION SIGNAL
RESPONSE SIGNAL
REVERSE RESPONSE SIGNAL
V/2
V
-V
-V/2
P5
P51
A9
P61
P6
A10
0

FIG.9


SELECTION SIGNAL
NON-SELECTION SIGNAL
RESPONSE SIGNAL
REVERSE RESPONSE SIGNAL
V
2v
v
V-2v
-V
-(V-2v)
-v
P7
A11
P8
A12
0

2175725

FIG.10

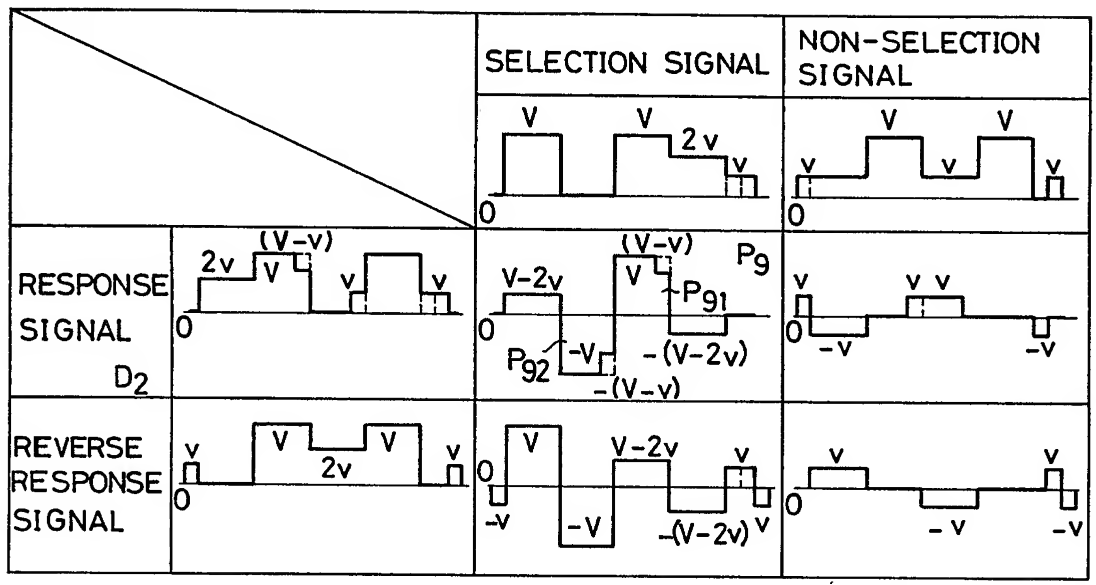


FIG.11

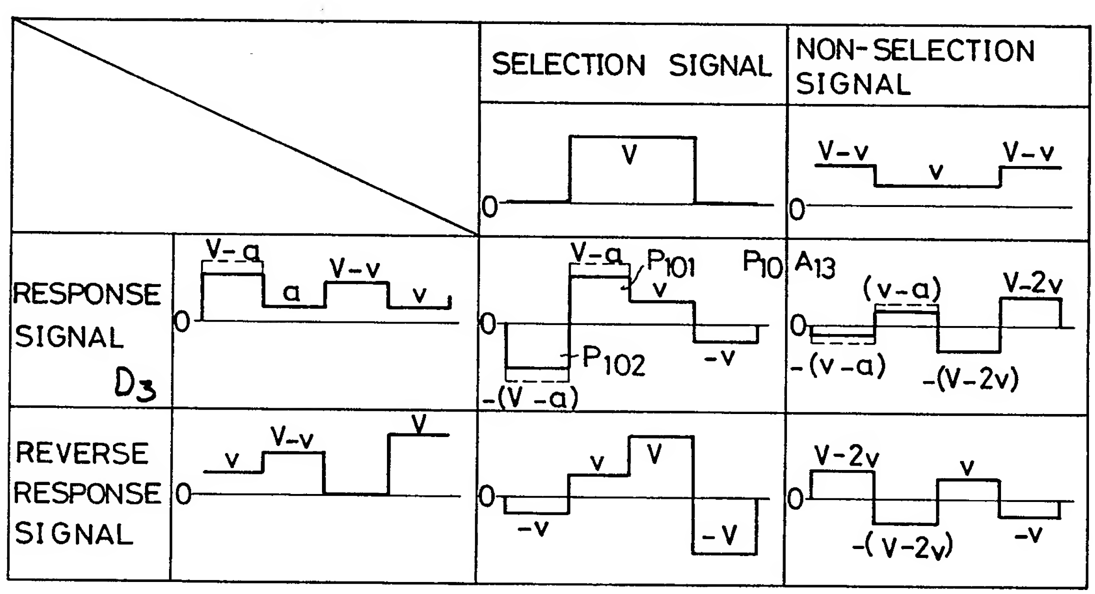


FIG.12

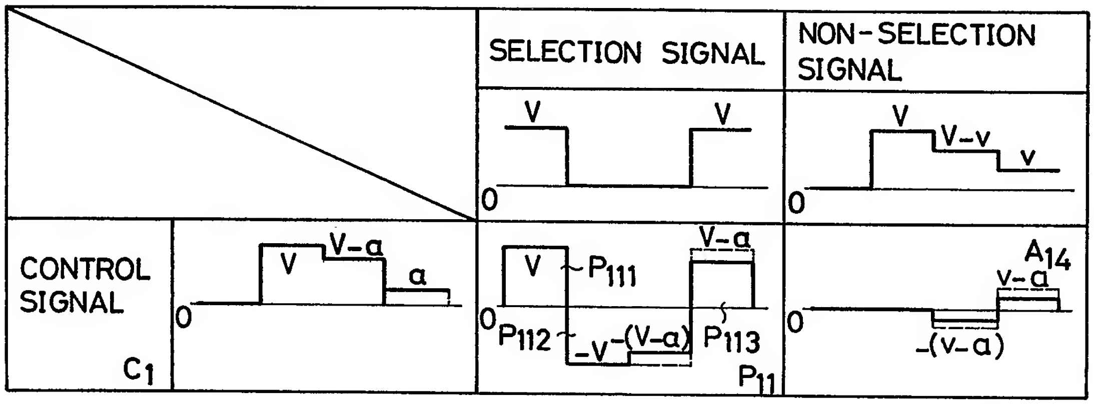


FIG.13

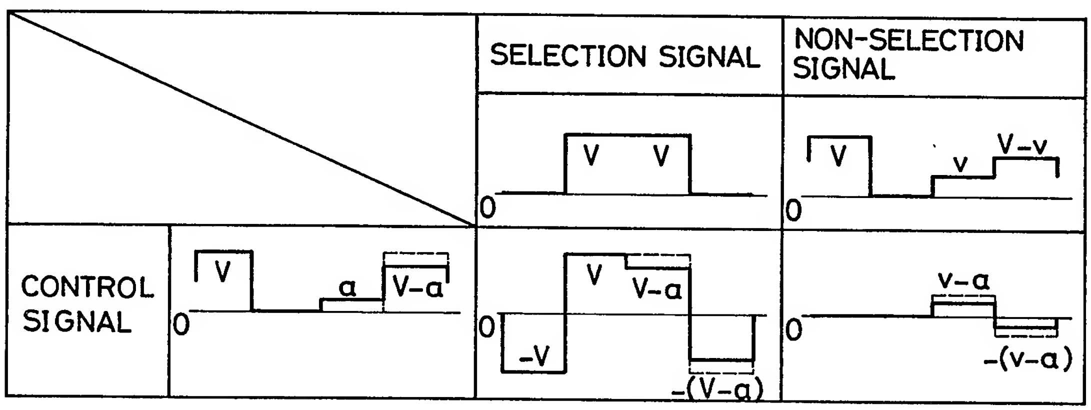


FIG.14

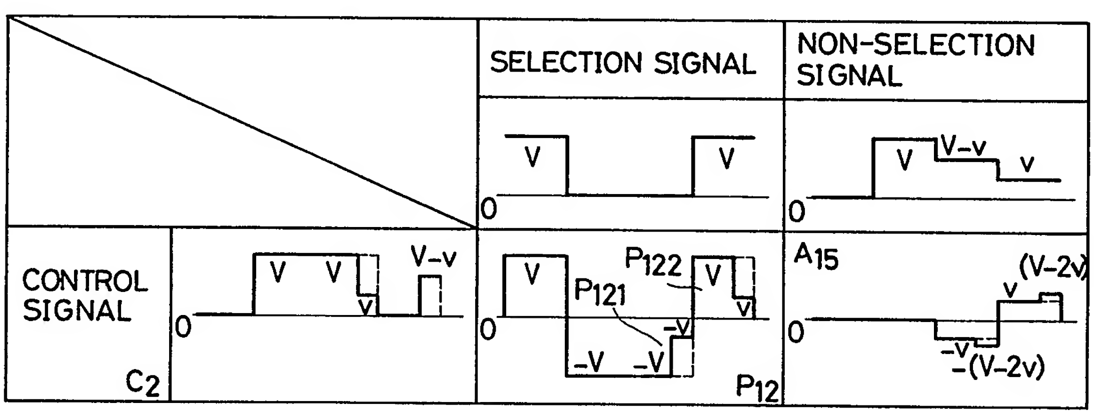


FIG.15

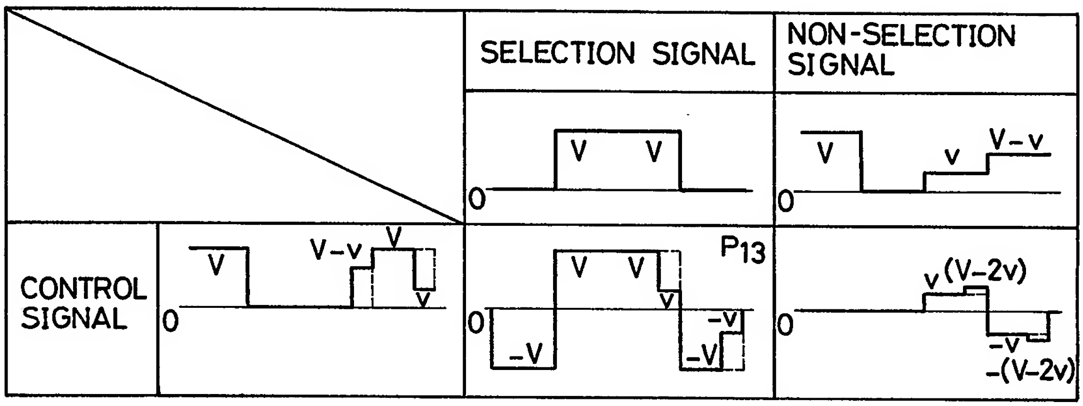

SELECTION SIGNAL
NON-SELECTION SIGNAL
CONTROL SIGNAL
V
V-v
v
0
-V
P13
V-v
(V-2v)
-(V-2v)

FIG.16

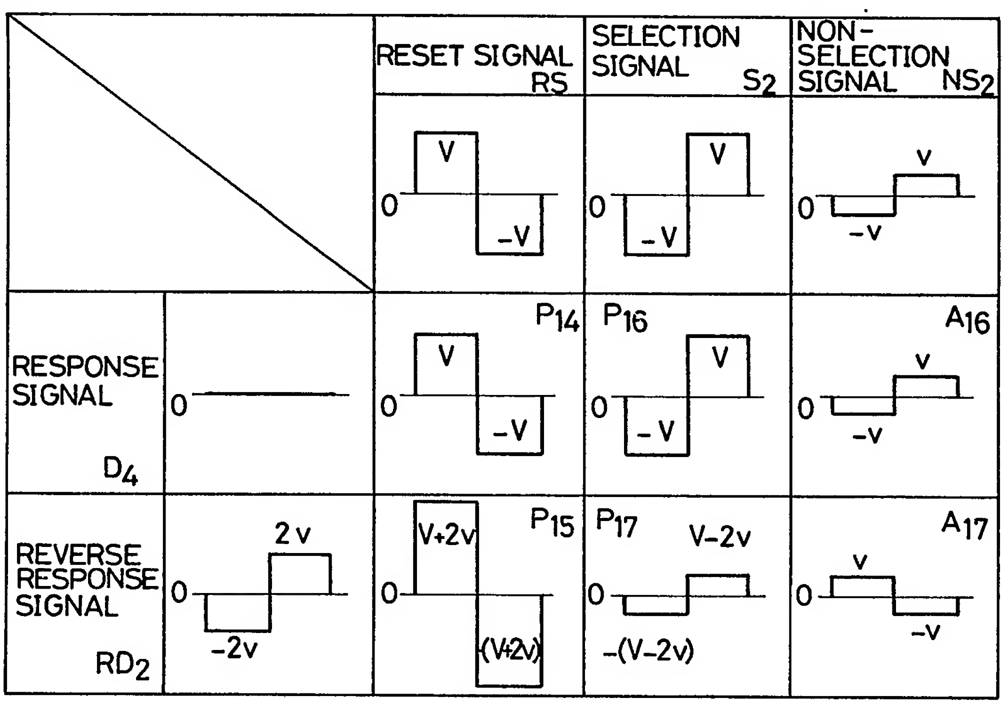

RESET SIGNAL RS
SELECTION SIGNAL S2
NON-SELECTION SIGNAL NS2
RESPONSE SIGNAL D4
REVERSE RESPONSE SIGNAL RD2
V
-V
v
-v
0
P14
P16
A16
P15
P17
A17
2v
-2v
V+2v
(V+2v)
V-2v
-(V-2v)

FIG. 17

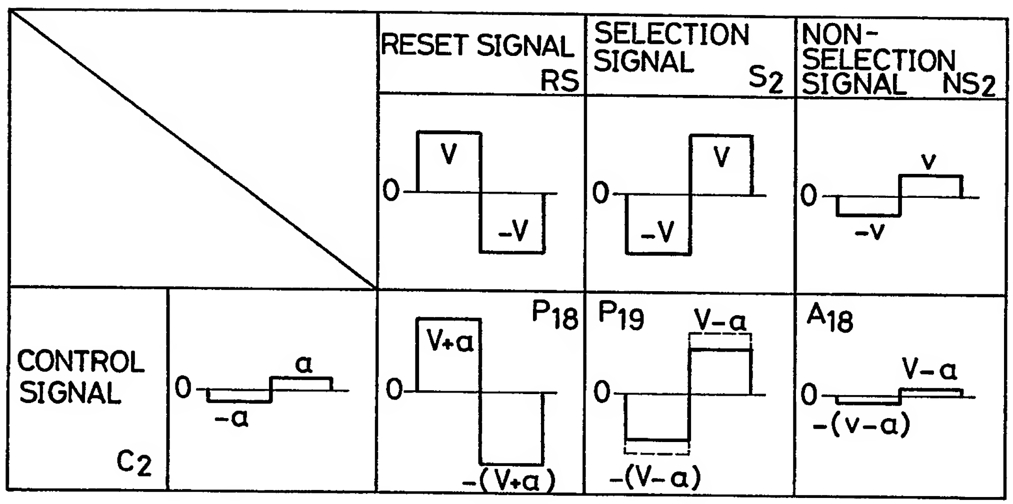

RESET SIGNAL RS
SELECTION SIGNAL S2
NON-SELECTION SIGNAL NS2
CONTROL SIGNAL C2
0
V
-V
a
-a
P18
V+a
-(V+a)
P19
V-a
-(V-a)
A18
-(v-a)

FIG. 18

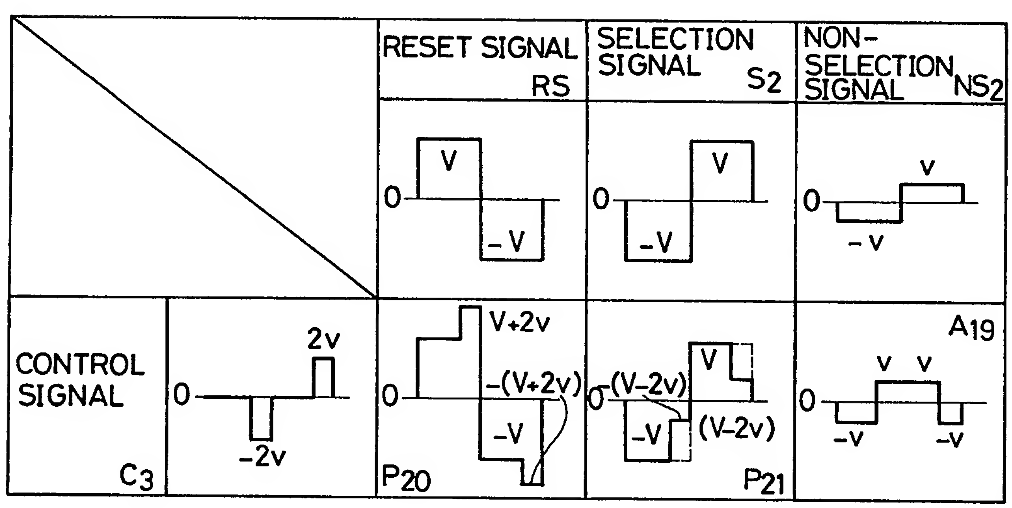

RESET SIGNAL RS
SELECTION SIGNAL S2
NON-SELECTION SIGNAL NS2
CONTROL SIGNAL C3
0
V
-V
2v
-2v
V+2v
-(V+2v)
P20
(V-2v)
P21
A19
v v
-v -v

FIG.19

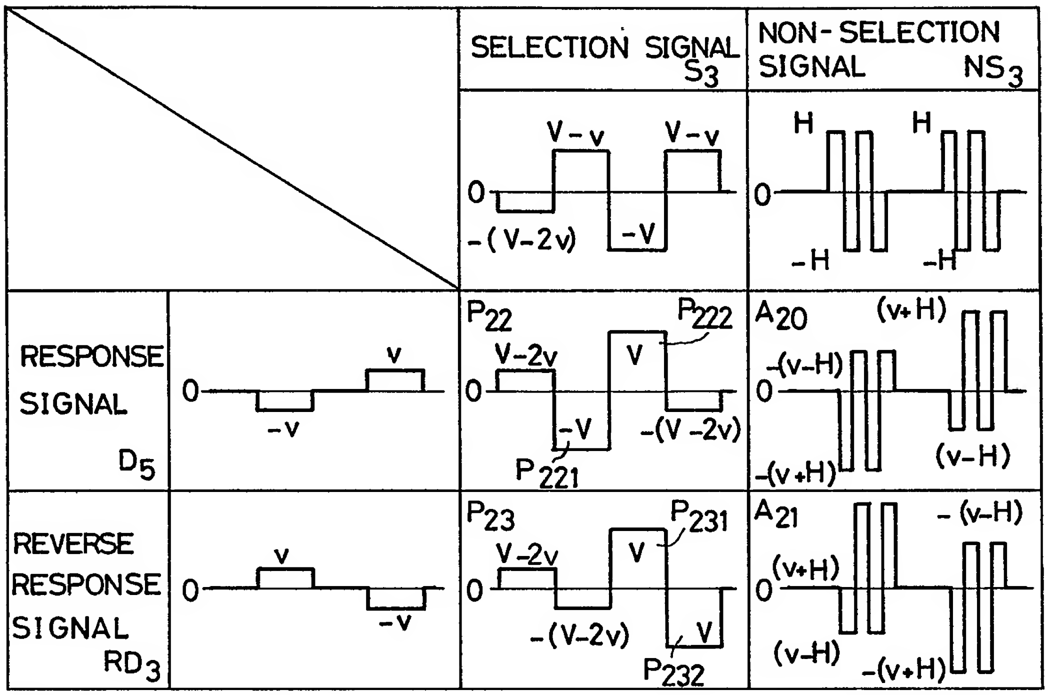

SELECTION SIGNAL S3
NON-SELECTION SIGNAL NS3
V-v
0
-(V-2v)
-V
H
-H
RESPONSE SIGNAL D5
v
-v
P22
P222
V-2v
P221
-(V-2v)
A20
(v+H)
-(v-H)
-(v+H)
(v-H)
REVERSE RESPONSE SIGNAL RD3
P23
P231
P232
A21
-(v-H)

FIG.20

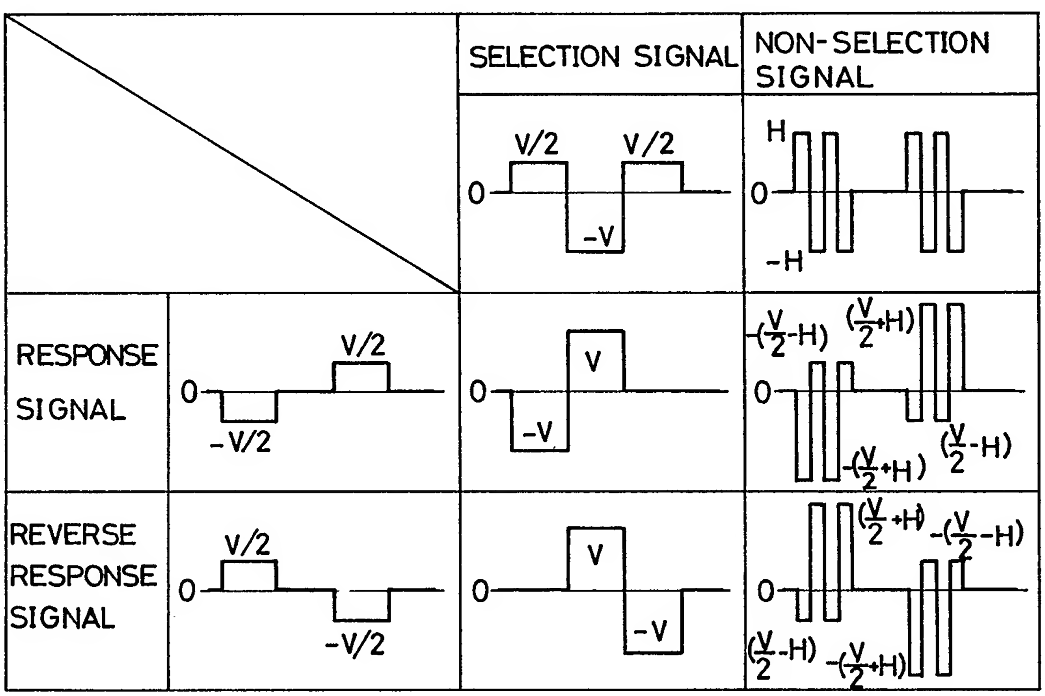

SELECTION SIGNAL
NON-SELECTION SIGNAL
V/2
0
-V
H
-H
RESPONSE SIGNAL
-V/2
V
-(V/2-H)
(V/2+H)
-(V/2+H)
(V/2-H)
REVERSE RESPONSE SIGNAL

FIG.21

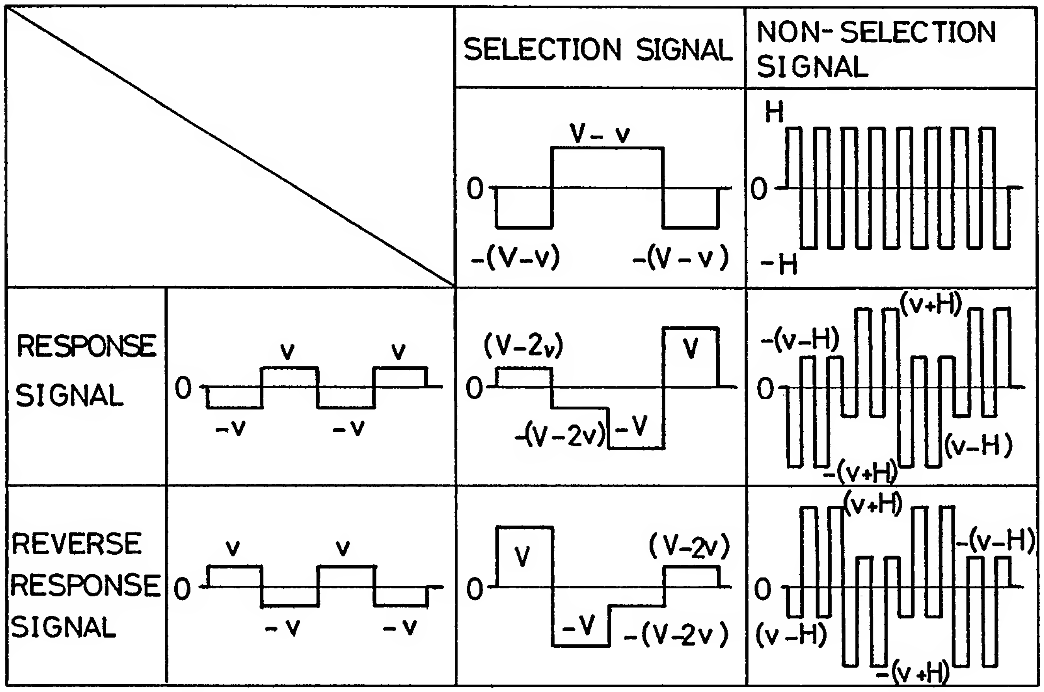

SELECTION SIGNAL
NON-SELECTION SIGNAL
V− v
0
−(V−v)
−(V − v)
H
0
−H
RESPONSE SIGNAL
0
v
v
−v
−v
(V−2v)
0
V
−(V−2v)
−V
−(v−H)
(v+H)
0
−(v+H)
(v−H)
REVERSE RESPONSE SIGNAL
0
v
v
−v
−v
V
(V−2v)
0
−V
−(V−2v)
(v+H)
−(v−H)
0
(v −H)
−(v +H)

FIG.22

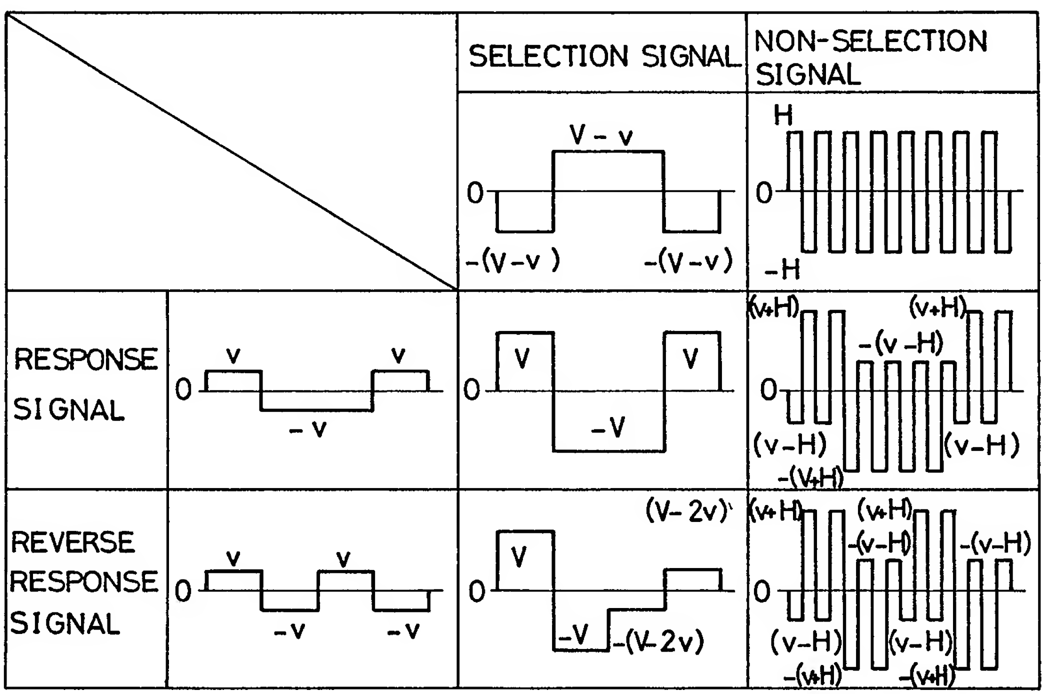

SELECTION SIGNAL
NON-SELECTION SIGNAL
V − v
0
−(V−v)
−(V−v)
H
0
−H
RESPONSE SIGNAL
0
v
v
− v
V
V
0
−V
(v+H)
(v+H)
−(v −H)
0
(v−H)
(v−H)
−(v+H)
REVERSE RESPONSE SIGNAL
0
v
v
−v
−v
(V− 2v)
V
0
−V
−(V−2v)
(v+H)
(v+H)
−(v−H)
−(v−H)
0
(v−H)
(v−H)
−(v+H)
−(v+H)

FIG.23

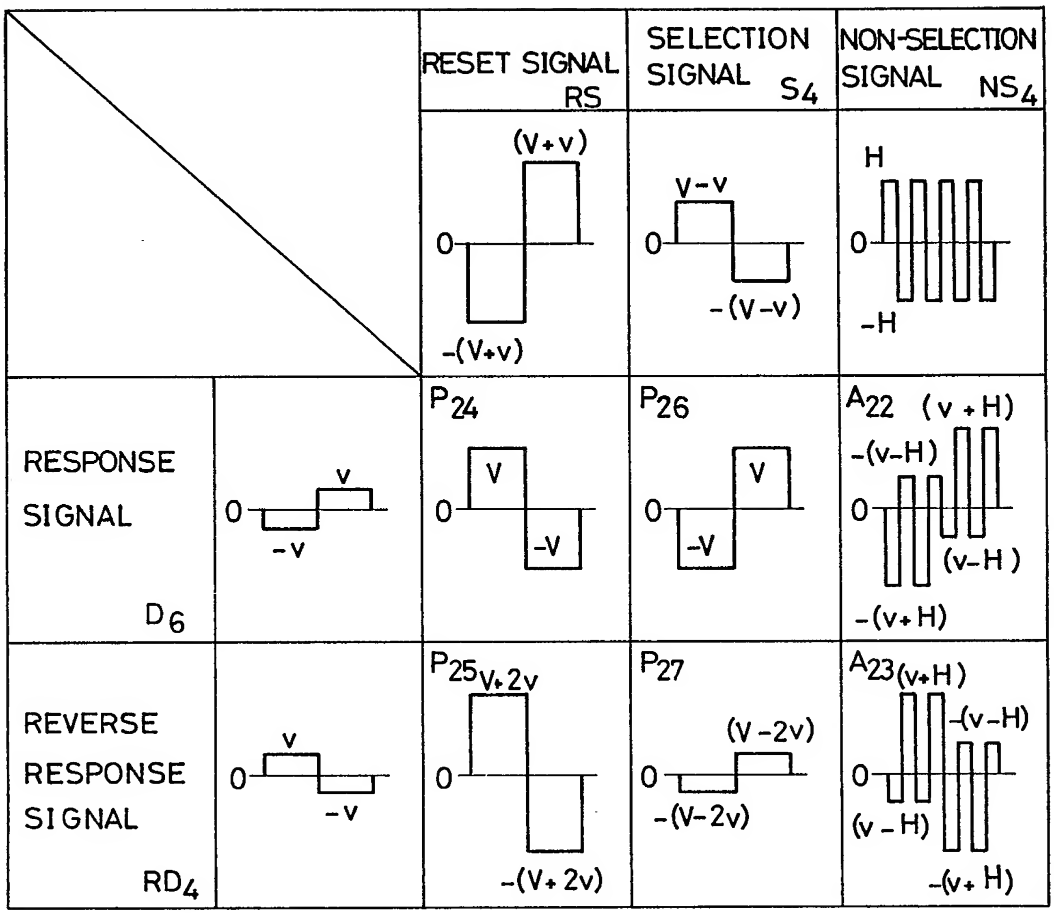

RESET SIGNAL RS
SELECTION SIGNAL S4
NON-SELECTION SIGNAL NS4
(V+v)
0
-(V+v)
V-v
0
-(V-v)
H
0
-H
RESPONSE SIGNAL D6
0
v
-v
P24
V
0
-V
P26
V
0
-V
A22 (v+H)
-(v-H)
0
(v-H)
-(v+H)
REVERSE RESPONSE SIGNAL RD4
v
0
-v
P25 V+2v
0
-(V+2v)
P27
(V-2v)
0
-(V-2v)
A23 (v+H)
-(v-H)
0
(v-H)
-(v+H)

FIG.24

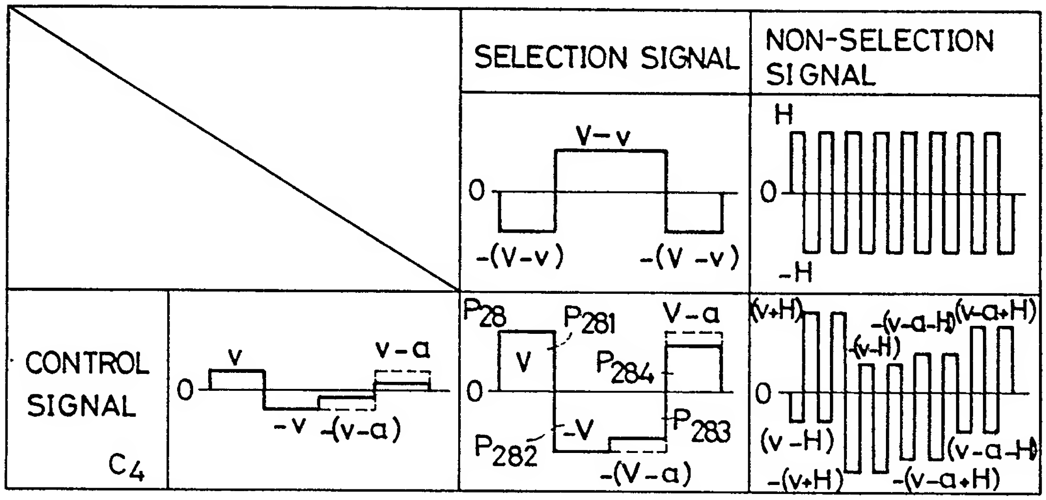
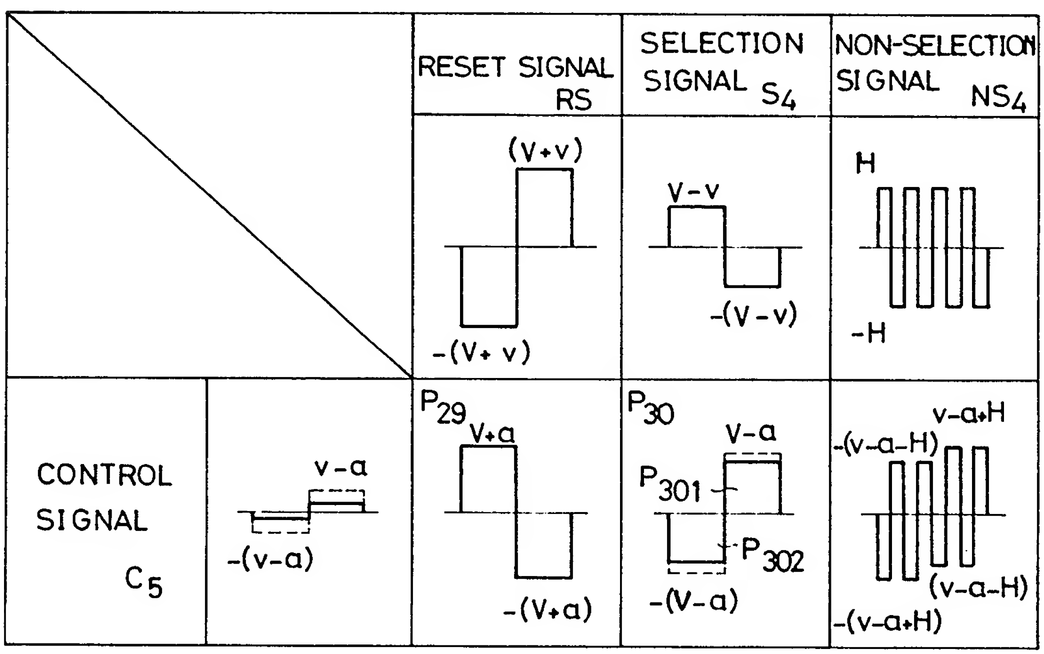

SELECTION SIGNAL
NON-SELECTION SIGNAL
V−v
0
−(V−v)
−(V −v)
H
0
−H
CONTROL SIGNAL
C4
0
v
v−a
−v
−(v−a)
P28
P281
V−a
V
P284
0
−V
P283
P282
−(V−a)
(v+H)
−(v−a−H)
(v−a+H)
(v−H)
0
(v −H)
(v−a−H)
−(v+H)
−(v−a+H)

FIG.25


RESET SIGNAL RS
SELECTION SIGNAL S4
NON-SELECTION SIGNAL NS4
(V+v)
−(V+ v)
V−v
−(V−v)
H
−H
CONTROL SIGNAL
C5
v−a
−(v−a)
P29
V+a
−(V+a)
P30
V−a
P301
P302
−(V−a)
v−a+H
−(v−a−H)
(v−a−H)
−(v−a+H)

SPECIFICATION

Improvements in or relating to electro-optical display devices

This invention relates to electro-optical display devices and more specifically to methods of driving electro-optical display devices of the kind employing an electro-optical material in which the display condition is controlled in accordance with the direction of an electric field applied thereto. In such material as at present known the rate of response is dependent upon the intensity of the electric field and the duration of pulses during which said electric field is applied. An example of a device of this kind is a display device in which an electric field is applied by means of crossed sets of transparent electrodes with a layer of ferro-electric liquid crystal material between the sets.

The use of ferro-electric liquid crystal material in place of the at present commonly used TN type of liquid crystal has long been considered, but the driving of such a device employing such material has hitherto presented such problems and difficulties that the widespread use of such devices has hitherto been more a matter of theoretical possibility for investigation than a matter of practical politics.

The display mode of ferro-electric liquid crystal and certain other forms of liquid crystal may be categorized into the complex refraction type of display mode and the guest host type of display mode. The driving methods customarily employed for driving devices having the conventional TN type of liquid crystal cannot be satisfactorily used for driving devices with ferro-electric liquid crystal because, unlike the TN type of liquid crystal, the display condition (brightness of display) in the ferro-electric type of crystal is controlled by changing the direction of the applied electric field. When a voltage, although it may be only of low level, is continuously applied in one direction, (i.e. is of one polarity) the ferro-electric liquid crystal may at last respond to it.

The driving methods so far proposed for driving display devices of the kind referred to sometimes allow, during time-shared non-selection periods, repeated application of small amplitude pulses of polarity opposite to that of the pulse used for display and, because of the characteristics of the electro-optical material employed, there is a bad loss of contrast in the display if the number of digits (i.e. picture elements) in a scan of the picture area is large—as, of course, is a requirement in many, if not the majority, of cases. The voltage waveforms applied in these known methods are far from being satisfactory, i.e. far from being substantially true AC voltage waveforms because the voltage of one polarity is applied for a considerably longer time than that of the other polarity. Because of this departure from true AC waveforms there occur the serious defects that, when the device is driven for a long time, the initially transparent electrodes for applying electric fields to the electro-optical material are liable to become blackened and/or the double colour pigment in such material is liable to become discoloured and/or the liquid crystal material may itself become deteriorated.

Moreover, it has hitherto been considered so difficult to obtain brightness gradation (intermediate tones) in the display provided by a device using ferro-electric liquid crystal or similar material that, so far as the present applicants are aware, no driving methods capable of giving gradation or intermediate tone effect in a display by such a device has yet been proposed.

The present invention seeks to overcome the foregoing defects and difficulties and to provide methods of driving display devices of the kind preferred to which are such that, even after a long period of driving, the initially transparent electrodes will not become blackened, double colour pigment will not become discoloured and the liquid crystal will not become deteriorated.

Another object of the invention is to provide methods of driving an electro-optical display device of the kind referred to which are such that good contrast in the display is obtained even when the number of digits is high.

A further object of the invention is to provide methods of driving an electro-optical display device of the kind referred to which are such as to produce intermediate tones or gradation in the display.

A still further object of the invention is to provide methods of driving an electro-optical display device of the kind referred to which are such as to permit the period of time sharing driving to be made a short one and therefore to enable a larger number of digits to be used in the display than would otherwise be possible.

According to this invention in one aspect, a method of driving an electro-optical display device of the kind in which display is obtained by applying an electric field to an electro-optical modulation substance having different response conditions in accordance with the direction of application of said field, is characterised in that the said electric field is produced by pulse groups composed of pulses of different polarities but similar in number and waveform and which combine to constitute substantially true AC driving waveforms.

According to this invention in another aspect, a method of driving an electro-optical display device for producing a display consisting of display elements and which comprises first and second sets of electrodes, the electrodes of one set crossing those of the other, and an electro-optical modulation substance

situated between said sets and having different response conditions in accordance with the direction of application thereto of an electric field provided between two electrodes one in each set, includes sequentially applying a selection signal to one first set electrode of respective display elements, and applying a non-selection signal thereto when a selection signal is not supplied; supplying a desired signal to the corresponding second set electrode; applying at a display element a pulse group which includes display control pulses of such duration and electric field intensity as to set the electro-optical modulation substance to the desired response condition with a voltage difference between said desired signal and said selection signal such as not to permit, after application of such display control pulse, the existence of a pulse which would change said response condition of said electro-optical modulation substance, said pulse group being composed of pulses which are of substantially the same waveform and of the same number but of different polarities; and applying at said display elements AC pulses to hold said electro-optical modulation substance to the said desired response condition in accordance with the voltage difference between said desired signal and said non-selection signal.

According to this invention in a further aspect, a method of driving an electro-optical display device for producing a display consisting of display elements and which comprises first and second sets of electrodes, the electrodes of one set crossing those of the oher and an electro-optical modulation substance situated between said sets and having different response conditions in accordance with the direction of application thereto of an electric field provided between two electrodes one in each set, includes supplying sequentially a display initialization signal to one first set electrode of respective display elements, the selection signal following such initialization signal and the non-selection signal while said initialization signal and said selection signal are not supplied; supplying a desired signal to the corresponding second set electrode; applying a pulse which sets said electro-optical modulation substance to the saturated reverse response condition in accordance with the voltage difference between said desired signal and said initialization signal; applying to said display elements a pulse group which includes display control pulses of such duration and electric field intensity as to set the electro-optical modulation substance to the desired response condition with a voltage difference between said desired signal and said selection signal such as not to permit, after application of such display control pulse, the existence of a pulse which would change said response condition of said electro-optical modulation substance, said pulse group being composed of pulses which are of substantially the same waveform and of the same number, but of different polarities; and applying at said display elements AC pulses to hold said electro-optical modulation substance to the said desired response condition in accordance with the voltage difference between said desired signal and said non-selection signal.

In the preferred methods of the invention intermediate tone or gradation is provided for. This may be obtained by modulating selected component pulses in the pulse groups in amplitude or duration.

The invention is illustrated in and explained with the assistance of the accompanying drawings, in which Fig. 1 shows, schematically, one example of a liquid crystal display device for which the methods of the invention are intended and Figs. 2 to 25 illustrate by means of voltage waveforms various different driving methods in accordance with this invention.

The display device represented in Fig. 1 comprises a first set of substantially transparent electrodes L_1 to L_7 and a set of crossing substantially transparent electrodes R_1 to R_5 associated with a layer (not shown) of an electro-optical modulation substance having different response conditions in accordance with the direction of the electric fields to which it is subjected. This layer is situated between the above-mentioned two sets of electrodes. Referring now to Figs. 1 and 2, SE (Fig. 1) is a selection circuit which produces a selection signal S_1 (Fig. 2) for sequentially selecting on a time sharing basis, one of the electrodes L_1 to L_7 and which also produces a non-selection signal NS_1 when a selection signal is not supplied. As shown in Fig. 2, the selection signal S_1 is composed of the voltages V and 2v—it is desirable for V/2 to be equal to or greater than *v*—and the non-selection signal NS_1 is composed of the voltages V and v.

DR is a drive control circuit which produces a response signal D_1 and a reverse response signal RD_1 (see Fig. 2) for the electrodes R_1 to R_5, the said response signal D_1 being applied to the crossing electrode of a response display element and the reverse response signal RD_1 being applied to the crossing electrode of a reverse response display element.

A pulse group P_1 is applied to the response display element, while a pulse group P_2 is applied to the reverse response display element. In the pulse group P_1, a pulse (V−2v) is first applied but the liquid crystal does not respond to it but reversely responds to the next reverse response pulse P_{11}. When the next display control pulse P_{12} is applied, the liquid crystal is saturated by it. Then, a pulse of voltage −(V−2v) is applied but the liquid crystal does not respond to this and does not enter the reverse response condition. As will be see from Fig. 2, in the case of the pulse group P_1, the number of component pulses of

different polarities and similar waveform are equal and combine to form a substantially true AC pulsed waveform.

After the supply of the pulse group P_1, an AC pulsed waveform A_1 or A_2 is applied by the non-selection signal NS_1, to keep the response condition. The AC pulsed waveforms A_1, A_2 are composed of pulses which are alike in waveform but differ only in polarity, and accordingly, even when these pulses are repeatedly applied, the liquid crystal is kept in the responsive condition.

In the pulse group P_2, after application of the response pulse P_{21}, a display control pulse P_{22} is applied for setting the liquid crystal in the reverse responsive condition. Thereafter, pulses of voltages (V−2v) and −(V−2v) are applied and the reverse responsive condition is therefore maintained. When the non-selection signal NS_1 is being supplied, an AC pulse A_1 or A_2 is applied and accordingly the reverse responsive condition is maintained.

To summarise, the pulse groups P_1, P_2 and the AC pulses A_1, A_2 are similar in waveform and number of component pulses but are different in polarity. The result, therefore is the attainment of substantially true pulsed AC waveforms and in consequence the substantially transparent electrodes do not become blackened, the liquid crystal material does not deteriorate and double colour pigment does not become discoloured, even after driving for a long time.

As regards operating voltages and by way of example only, if the display device is a ferro-electric liquid crystal cell with a liquid crystal layer thickness of 10μm, the saturated response condition and the saturated reverse response condition can be obtained by making the voltage V 10 volts if the pulse duration of the display control pulse is 250μ sec.

Figs. 3 and 4, which, in view of the description already given of Fig. 2, will, it is thought, be self explanatory from the legends thereon and show other examples of selection, non-selection, response and reverse response signals which may be used and which will produce results similar to those produced if the waveforms of Fig. 2 are used, and which provide the same advantages.

Figs. 5 and 6 illustrate driving methods which are such that the duration of the pulse applied to a display element during a non-selection period can be made half or less than half of the duration of the display control pulse used in the methods illustrated by Figs. 2, 3 and 4. As will be seen, the non-selection signal waveforms in Fig. 5 and Fig. 6 are modifications, respectively, of the non-selection signal waveforms in Figs. 3 and 4 and AC pulses A_3, A_4 (in Fig. 5) or A_5, A_6 (in Fig. 6) of short duration are applied during the non-selection period. The advantages obtained by using waveforms as exemplified by Figs. 5 and 6 as compared with waveforms as shown in Figs. 2, 3 and 4 are that the response condition and the reverse response condition of the display elements are more reliably assured and satisfactory operation is obtained with a larger tolerance as regards temperature change and equality of liquid crystal thickness.

In the methods of Figs. 2 to 6, when an AC pulse is applied, following a pulse group including a display control pulse, pulses of the same polarity occur continuously, i.e. one directly after the other. For example, in Fig. 2, since the polarity of the last pulse in each of the pulse groups P_1, P_2 is the same as that of the first pulse of the AC pulse A_1, pulses of the same polarity follow one another when the pulse group P_1 or P_2 is changed to the AC pulse A_1. This has the disadvantage of tending to produce a somewhat lower tolerance as regards temperature change and equality of liquid crystal thickness.

Figs. 7 to 9 illustrate methods which avoid this disadvantage. In Fig. 7, the polarity of the last pulses of the pulse groups P_3, P_4 is the same and of reversed polarity with respect to the first pulses of the AC pulses A_7, A_8. As a result, pulses of the same polarity never follow one another in a continuing manner and the described disadvantage as regards tolerance is avoided.

In Fig. 8, the last pulses of the pulse groups P_5, P_6 are caused to be of reversed polarity with respect to the first pulses of AC pulses A_9, A_{10}, by applying a narrow pulse of voltage V/2 or voltage O at the leading part or trailing part of each signal.

In the method illustrated by Fig. 9, the waveforms are modifications of those of Fig. 2, the modification being that a narrow pulse of voltage v or voltage O is at the leading part or trailing part of each signal. In this way, the last pulses of the pulse groups P_7, P_8 are caused to be of reversed polarity to the first pulses of the AC pulsed waveforms A_{11}, A_{12}.

As will be seen, in the methods illustrated by Figs. 7 to 9, the waveforms and number of component pulses of different polarities are the same, and therefore substantially true pulsed AC driving, with the advantages already stated, is obtained.

Similar results can be obtained by adding to the waveforms of Figs. 3 to 6 short pulses similar to those added in Fig. 9.

It is possible, with this invention, to obtain intermediate tones in the display i.e. to obtain gradation in the display. In Fig. 10 intermediate tone or gradation effect is obtained by modifying the response signal waveforms shown in Fig. 9 in accordance with the desired gradation. Referring to Fig. 10, part of the first voltage pulse V of the response signal D_2 is removed to leave a voltage (V−v) and a voltage pulse *v* of the same width as the above mentioned removed part is added to the next voltage V. Accordingly part of the display control pulse P_{91} of the pulse group P_9

is removed and the pulse P_{92} which is of reversed polarity but of the same waveform as the said pulse P_9 also has a corresponding part removed. As will be appreciated, desired intermediate tones or gradations can be readily obtained by controlling the width of removed voltage parts *v* in accordance with the gradation desired. Moreover, substantially true pulsed AC driving is realized because, again, the pulse waveforms are alike as regards waveform and numbers of component pulses but are different as regards polarity.

Fig. 11 illustrates a method in which intermediate tone effect is obtained by modifying the waveforms of Fig. 3. In Fig. 11, the voltage V (shown by the broken line) of the response signal D_3 is changed to the voltage (V–a) where *a* is of a value in accordance with the gradation required and the next voltage (which in Fig. 3 is zero) is increased to the voltage *a*. Accordingly the voltage of the display control pulse P_{101} of pulse group P_{10} is caused to become (V–a), thus producing the required intermediate tone. The pulse P_{102} which is of reversed polarity with respect to, and of the same waveform as, the display control pulse P_{101} is also caused to assume the voltage –(V–a) so that substantially true pulsed AC driving results. Moreover, since the first two pulses of the AC pulsed waveform A_{13} are reduced only by the amount *a*, the tolerance as regards temperature change and thickness of electro-optical material layer is good. The circuitry required for modifying Fig. 3 in this manner is simple because nothing more than a change in voltage value is required. The just described method of modifying Fig. 3 to produce an intermediate tone effect can also be used to modify any of Figs. 3 to 7 for the same purpose i.e. to produce gradation of tone. To put the matter in another way, the method is adapted for use when the display control pulse for obtaining a response condition and a pulse which differs therefrom only in polarity, and the display control pulse for obtaining a reverse response condition and a pulse which differs therefrom only in polarity are respectively shifted in time. The said method cannot be used, however, to modify, for example, waveforms such as those shown in Fig. 8, in which the display control pulse P_{51} of the pulse group P_5 overlaps in time the pulse P_{61} of the pulse group P_6.

The methods so far described for producing intermediate tone effect have the defect of involving difficulty when dynamic images have to be displayed i.e. when quickly changing images are required to be displayed. For example, in Fig. 11, when the pulse group P_{10} is applied to display elements in the saturated response condition, the liquid crystal is set to the unsaturated reverse response condition by the pulse P_{102} and is then set from said condition to the unsaturated response condition by the pulse P_{101}. However, when said pulse group P_{10} is first applied to the display elements in the saturated reverse response condition, the said saturated reverse response condition is maintained by the pulse group P_{102}, and since the pulse P_{101} is applied in this condition, the liquid crystal is set to an unsaturated response condition which is different from that described above. Accordingly the final response condition obtained depends on the preceding condition and it is therefore difficult to obtain the desired response condition.

Fig. 12 shows how this disadvantage can be avoided and the desired gradation can be produced, irrespective of the preceding condition. In Fig. 12, the selection signal is sequentially supplied to the electrodes L_1 to L_7 as in the preceding figures and the non-selection signal is also supplied during the non-selection period. A control signal C_1 is supplied to the crossing electrodes R_1 to R_5. The control signal C_1 is composed of voltages O, V, (v–a) and *a*, the voltage *a* being changed in accordance with the gradation desired. After a response pulse P_{111} dependent on the voltage difference between the selection signal and the control signal C_1 is applied, a reverse response pulse P_{112} is applied. Therefore, the liquid crystal is set to the saturated reverse response condition, irrespective of the preceding condition. In effect what may be termed initialization is carried out. Accordingly, the desired response condition is obtained by the display control pulse P_{113} of voltage (V–a). When the required intermediate tone is thus obtained, the condition is kept by the AC pulse A_{14} of value (v–a). For instance, when the value *a* is O, the pulse P_{113} assumes the voltage V for entering the saturated response condition, and when the voltage V is thus assumed, the pulse P_{113} becomes O and the saturated reverse response condition is held by the pulse P_{112}.

As already explained, the liquid crystal is set to the saturated reverse response condition before the pulse for generating the intermediate tone and therefore a stabilized intermediate tone is obtained even in the case of a display of quickly moving or changing images.

Fig. 13 illustrates a method similar to that of Fig. 12, the waveforms of Fig. 13 differing from those of Fig. 12 only in that their polarities are reversed from those shown in Fig. 12. Fig. 13 therefore needs no further description.

Figs. 14 and 15 illustrate methods in which the intermediate tones are produced by adjusting pulse durations. The control signal C_2 in Fig. 14 is a modification of the control signal C_1 in Fig. 12. In the case of Fig. 12 the durations of the voltages V and (V–v) are controlled in accordance with the gradation required. As a result, the pulses P_{121} and P_{122} of pulse group P_{12} are caused to assume the

staircase forms shown with voltages V and v, the duration of voltage V being changed in accordance with the gradation and the intermediate tone effect being thus obtained. The AC pulse A_{15} also assumes the staircase form shown and since this pulse is the same as the above pulse except for its polarity, the required intermediate tone is held.

Fig. 15 differs from Fig. 14 only in that the pulse group P_{13} applied for display is of opposite polarity to the pulse P_{12} in Fig. 14. Fig. 15 therefore needs no further description.

There will now be described with reference to Fig. 16 a method wherein the display is initialized at a time before the selection signal is applied and thereafter the condition is changed. In Fig. 16, a selection signal S_2 composed of voltages $-V$ and V is sequentially supplied to the electrodes L_1 to L_7 (Fig. 1) and a reset signal RS comprised of voltages V and $-V$ is supplied at a preceding time. During non-selection periods, a non-selection signal NS_2 consisting of voltages $-V$ and v is supplied. It is desirable to make V/4 equal to or less than *v* and to make *v* equal to or less than V/2.

A response signal D_4 of zero voltage or a reverse response signal D_5 composed of voltages $-2V$ and 2V is supplied to the crossing electrodes R_1 to R_5.

First, a pulse group P_{14} or P_{15} is applied by the reset signal RS and thereby the liquid crystal is reset to the saturated reverse response condition. It is then set to the response condition by applying a pulse group P_{16} with the selection signal S_2 and response signal D_4. It is set to the reverse response condition by applying a pulse group P_{17} with the selection signal S_2 and reverse response signal RD_2. The pulse group P_{17} is used for holding the saturated reverse response condition set by the pulse group P_{15}.

When the non-selection signal NS_2 is supplied, the AC pulse A_{16} or A_{17} is applied, maintaining the response condition or reverse response condition.

As will be appreciated, in the method illustrated by Fig. 16 each signal supply period is only 1/2 of that in each previously described method and therefore the number of digits scanned in a given period can be doubled, making multiple-digit driving possible. In other words, the time taken to make a single scan can be reduced to 1/2 for the same number of digits, and crosstalk effects accordingly reduced and contrast improved.

Figs. 17 and 18 illustrate ways of modifying the method of Fig. 16 to obtain intermediate tone or gradation effect. In Fig. 17, the reset signal, selection signal and non-selection signal are the same as in Fig. 16 and a control signal C_2 of voltage *a*, supplied to the crossing electrodes R_1 to R_5 (Fig. 1) is controlled in accordance with the gradation. A pulse group P_{18} of voltages $(V+a)$ and $-(V+a)$ is applied with the reset signal RS and control signal C_2 and the liquid crystal is thus reset to the saturated reverse response condition. Thereafter, a pulse group P_{19} of voltages $-(V-a)$ and $(V-a)$ is applied with the selection signal S_2 and the control signal C_2 and the desired response condition is thus obtained. An AC pulse A_{18} of voltages $-(v-a)$ and $(v-a)$ is applied with the non-selection signal NS_2 and control signal C_2 to hold said response condition.

In Fig. 18, gradation is obtained by pulse duration adjustment, the durations of the voltages 2v and $-2v$ of the control signal C_3 being controlled in accordance with the gradation. In Fig. 18 the liquid crystal is reset to the saturated reverse response condition by the pulse group P_{20}. Thereafter, it is set to the desired intermediate response condition by the pulse group P_{21} and this response condition is held by the AC pulse A_{19}. The pulse group P_{21} produces the desired intermediate tone since the durations of the voltages V and $-V$ change in accordance with the gradation.

In the methods illustrated by Fig. 17 and Fig. 18, the liquid crystal is reset to the saturated reverse response condition before rewriting of the display and therefore a stable desired intermediate tone can be produced irrespective of the preceding response condition.

There will now be described, with reference to Fig. 19, a method wherein a high frequency AC pulse is superposed as the non-selection signal.

In Fig. 19, while the selection signal S_3 is not supplied, a non-selection signal NS_3 is produced. The selection signal S_3 is composed of the voltages $-(V-2v)$, $(V-v)$ and $-V$ and the non-selection signal NS_3 is composed of the AC pulses of voltages O, and H.

A response signal D_5 or reverse response signal RD_3 is applied to the crossing electrodes R_1 to R_5 (Fig. 1), the response signal D_5 being applied to a crossing electrode of a response display element, and the reverse response signal RD_3 being applied to the crossing electrode of a reverse response display element.

With supply of above signals, the pulse group P_{22} is applied to the response display element, and the pulse group P_{23} is applied to the reverse response display element. In the case of pulse group P_{22}, a pulse of voltage $(V-2v)$ is applied but the liquid crystal does not respond to it. When the next reverse response pulse P_{221} is applied, the liquid crystal responds reversely to it. But, since the display control pulse P_{222} is applied next, the liquid crystal is set to the saturated response condition. Thereafter, a pulse of voltage $-(V-2v)$ is applied, but the liquid crystal does not respond to this pulse and is not set to the reverse response condition. In the pulse group P_{22}, the component pulses are the same in

number and waveform but are different in their polarities and accordingly substantially true AC pulsed driving is obtained.

After the pulse group P_{22} is applied, an AC pulse A_{20} or A_{21} which is obtained by superposing a high frequency AC pulse on a pulse $\pm v$ which is less than the response pulse applied with the non-selection signal NS_3, is applied and the response condition is thus held. Since the AC pulses A_{20}, A_{21} are composed of narrow AC pulses which are the same in waveform but different only in the polarity, the liquid crystal is held at the response condition even when such pulses are applied repeatedly. In the case in which the liquid crystal material is ferro-electric or similar liquid crystal having negative dielectric anisotropy, a particularly stable condition holding force is obtained because the high frequency AC pulse causes the liquid crystal molecules to be arranged so as to be substantially parallel to the electrode substrate planes.

In the case of pulse group P_{23}, after the pulse of $\pm(V-2v)$ to which the liquid crystal does not respond is applied, the response pulse P_{231} is applied. Next, the display control pulse P_{232} is applied for setting the reverse response condition. While the non-selection signal NS_3 is supplied, the AC pulse A_{20} or A_{21} is applied and the reverse response condition is held.

Again, since the pulse groups P_{22}, P_{23} and the AC pulses A_{20}, A_{21} are alike as regards the number of component pulses and waveforms but are of different polarities, substantially true pulsed AC driving is obtained and defects such as gradual blackening of transparent electrodes, deterioration of the liquid crystal and discolouration of double-colour pigment are greatly reduced if not entirely eliminated.

As regards practical values and purely by way of non-limiting example, the saturated response condition or saturated reverse response condition of a ferro-electric liquid crystal layer with a thickness of 10μm can be obtained by choosing 10 volts for the value of V if 250μ sec is the duration of the dispoay control pulse.

The frequency of the high frequency AC pulse should be in integral relationship with the response pulse frequency and is preferably at least twice—desirably four or more times—the said response pulse frequency. The pulse amplitude H is adequately determined if it is chosen at such a value that the response condition is kept stable having regard to its relation with the dielectric anisotropy of the ferro-electric liquid crystal, but it is usually desirable to choose the value of H at about the response pulse amplitude V or rather less.

Figs. 20, 21 and 23 illustrate further methods in accordance with the invention. In each of the figures the driving realised is generally similar to that obtained with the method of Fig. 19. Figs. 20, 21 and 23 are so similar that detailed description of Fig. 23 will suffice for all three, the legends on the three figures being enough, it is thought, to make the differences apparent.

First will be described the case where the display is reset at a time before the supply of the selection signal and thereafter the condition is changed. Referring to Fig. 23, a selection signal S_4 composed of voltages $V-v$ and $-(V-v)$ is sequentially applied to the electrodes L_1 to L_7 (Fig. 1) and a reset signal RS composed of voltages $-(V+v)$ and $(V+v)$ is applied at the preceding time. During a non-selection period, a non-selection signal NS_4 comprised of voltages of $+H$ and $-H$ is applied. A response signal D_6 composed of voltages $-v$ and v or a reverse response signal RD_4 composed of voltages of v and $-v$ is applied to the crossing electrodes R_1 to R_5 (Fig. 1)

First, a pulse group P_{24} or P_{25} is applied by supply of the reset signal RS and thereby the liquid crystal is reset to the saturated reverse response condition. It is set to the response condition by applying the pulse group P_{26} with the selection signal S_4 and the response signal D_6, and can also be set to the reverse response condition by applying the pulse group P_{27} with the selection signal S_4 and reverse response signal RD_4. The pulse group P_{27} holds the saturated reverse response condition set by the pulse group P_{24} or P_{25}.

When the non-selection signal NS_4 is supplied, the AC pulse A_{22} or A_{23} is applied and thereby the response condition or reverse response condition is held.

With this method, because the supply period of each signal can be made only 1/2 or 2/3 of that in the methods previously described (for example in the method illustrated by Fig. 2) the number of digits scanned in a given period can be made twice or 1.5 times that scanned in the said previously described methods, making multi-digit drive possible. In other words, for a given number of digits per scan, a single scanning period can be reduced to 1/2 or 2/3 of what it was in a previously described method with consequent reduction of crosstalk and improvement in contrast.

Figs. 24 and 25 illustrate modifications of the methods of Figs. 22 and 23 respectively for the production of gradation or intermediate tone effects. In Figs. 24 and 25, the reset signal, selection signal and non-selection signal are the same as in Figs. 22 and 23 respectively and a voltage component *a* which is controlled in accordance with the gradation is included in the respective control signals C_4 and C_5 supplied to the crossing electrodes R_1 to R_5 (Fig. 1). In Fig. 24, a response pulse P_{281} followed by a reverse response pulse P_{282} are first applied the values of these pulses being determined by the difference (apparent in P_{28}) between the selection signal and the control

signal C_4, and accordingly the liquid crystal is initialised in the saturated reverse response condition. Thereafter, the saturated reverse response condition is held by the unsaturated reverse response pulse P_{283} and finally the unsaturated response pulse P_{284} is applied and the desired displayed intermediate tone is obtained.

In Fig. 25, the condition is reset to the saturated reverse response condition by the pulse P_{29} with the reset signal RS and control signal C_5. Thereafter the saturated reverse response condition is held by the unsaturated reverse response pulse P_{302} in accordance with the voltage difference (apparent in P_{30}) between the selection signal S_4 and the control signal C_5 and the desired displayed intermediate tone is obtained by application of the unsaturated response pulse P_{301}. Thereafter, a high frequency AC pulse is applied by the non-selection signal and control signal to hold said response condition.

As will be clear from description already given herein, the display of a desired intermediate tone or gradation can be obtained either by modulation, in accordance with the gradation required, of a voltage component *a* in the control signal or by pulse width modulation. In either case, it is important that the liquid crystal is reset to the saturated reverse response condition before the pulse for displaying the intermediate tone is applied. If the pulse for displaying the intermediate tone only is supplied, the response condition may be changed by the display condition before application of the pulse and accordingly stable display of the desired intermediate tone is not secured. For example, if, in order to display an intermediate tone, only an unsaturated reverse response pulse and an unsaturated response pulse are applied to the picture elements when in the saturated response condition, a picture element, set in the unsaturated reverse response condition by the unsaturated reverse response pulse is returned to the saturated response condition by the opposite unsaturated response pulse having the same waveform as the next unsaturated reverse response pulse and therefore the unsaturated response condition (intermediate tone) cannot be displayed in some cases.

However, in the methods illustrated by Figs. 24 and 25, since the liquid crystal is initialized to the saturated reverse response condition before rewriting of a display, the intermediate tone will be displayed stably irrespective of the preceding response condition.

The invention is not limited to the use of the particular waveforms shown in Figs. 2 to 25 and various modifications can be made. For example, bias voltage, can, if required, be added to the waveform illustrated.

The invention may be applied not only to the driving of ferro-electric liquid crystal display devices but to the driving of any form of display device using a material in which the display condition is controlled in accordance with the direction of an applied electric field and in which the response rate changes in accordance with the applied field intensity and pulse duration. Examples of such display devices are those using a ferro-electric substance such as PLZT, and those utilizing electrophoresis (so called EPID display devices).

The invention can be used with advantage in the driving of colour display arrangements including colour filters for the three colours of red, green and blue.

To recapitulate, because, in the methods provided by the present invention, the component pulses of different polarities in the pulse groups applied to the display elements, are similar in waveform and numbers, transparent electrodes employed to apply electric fields to the electro-optical material do not become blackened, double colour pigment in said material does not discolour and the said material does not deteriorate, even after driving for a long time. Moreover, the application of an AC pulse for holding the response condition during a non-selection period, results in good contrast being obtained even when the number of display digits is high.

Another advantage of the invention is that it lends itself to the display of intermediate tones or gradations—a thing which has hitherto been considered very difficult if not satisfactorily possible in display devices of the kind referred to and or using electro-optical material having the characteristics described above.

In addition, in carrying out the invention, the duration of the periods of signals to be supplied to the respective electrodes can be greatly shortened by resetting the display at a timing before application of a selection signal, so that many digits can be scanned within a short period and the number of display digits can be greatly increased. In other words, for a given number of digits per scan, the rewriting time of the display can be much curtailed, with consequent reduction or elimination of crosstalk and the obtaining of improved contrast.

Further, a very stable display of intermediate tones is obtainable—a great advantage in many cases and notably in the case of the display of television pictures.

The response pulse and reverse response pulse need not include a high frequency component and, therefore, good driving by means of low voltages is readily obtainable. In those methods of the invention in which an AC pulse with a high frequency superposed AC pulse is used during non-selection periods for holding the response condition, good contrast is still obtained even when the number of digits is high. In addition, in cases in which a ferro-electric or similar liquid crystal having negative dielectric anisotropy is used in the

display device, the high frequency AC pulse component causes the liquid crystal molecules to be arranged substantially parallel to the electrode substrate planes—and this too tends towards a stable condition holding force being obtained with high contrast and low crosstalk in the display. Furthermore, since the low frequency bias pulse is lower than the response pulse during non-selection periods, the high frequency superposed AC pulse is not required to be of larger amplitude and in general low voltage driving is readily possible.

The various waveforms shown in Figs. 2 and 25 in order to explain the driving methods illustrated by the figures are not complex or difficult to generate and any circuitry, well known per se to those skilled in the art, can be used to generate them. It is therefore not thought necessary to an understanding of the invention or to enable it to be carried into effect, to show circuits for generating the waveforms.

CLAIMS

1. A method of driving an electro-optical display device of the kind in which display is obtained by applying an electric field to an electro-optical modulation substance having different response conditions in accordance with the direction of application of said field, characterised in that the said electric field is produced by pulse groups composed of pulses of different polarities but similar in number and waveform and which combine to constitute substantially true AC driving waveforms.

2. A method as claimed in claim 1 wherein intermediate tone or gradation effect in the display is obtained by modulating in accordance with the gradation the amplitudes of selected component pulses in the driving waveforms.

3. A method as claimed in claim 1 wherein intermediate tone or gradation effect in the display is obtained by modulating in accordance with the gradation the durations of selected component pulses in the driving waveforms.

4. A method as claimed in claim 2 or 3 wherein the driving waveforms include an initial component pulse for setting the electro-optical modulation substance into its saturated reverse response condition before the writing in of a display.

5. A method as claimed in any of the preceding claims wherein the driving waveforms include a superimposed high frequency AC component.

6. A method of driving an electro-optical display device for producing a display consisting of display elements and which comprises first and second sets of electrodes, the electrodes of one set crossing those of the other, and an electro-optical modulation substance situated between said sets and having different response conditions in accordance with the direction of application thereto of an electric field provided between two electrodes one in each set, said method including sequentially applying a selection signal to one first set electrode of respective display elements, and applying a non-selection signal thereto when a selection signal is not supplied; supplying a desired signal to the corresponding second set electrode; applying at a display element a pulse group which includes display control pulses of such duration and electric field intensity as to set the electro-optical modulation substance to the desired response condition with a voltage difference between said desired signal and said selection signal such as not to permit, after application of such display control pulse, the existence of a pulse which would change said response condition of said electro-optical modulation substance, said pulse group being composed of pulses which are of substantially the same waveform and of the same number but of different polarities; and applying at said display elements AC pulses to hold said electro-optical modulation substance to the said desired response condition in accordance with the voltage difference between said desired signal and said non-selection signal.

7. A method as claimed in claim 6 and which includes controlling the effective voltage value of said display control pulse in accordance with desired intermediate tone in or gradation of the display and controlling the waveform of said desired signal so that the effective voltage value of a pulse of substantially the same waveform and opposite polarity to that of the said display control pulse in said pulse group is made equal to that of said display control pulse.

8. A method of driving an electro-optical display device for producing a display consisting of display elements and which comprises first and second sets of electrodes, the electrodes of one set crossing those of the other and an electro-optical modulation substance situated between said sets and having different response conditions in accordance with the direction of application thereto of an electric field provided between two electrodes one in each set, said method including supplying sequentially a display initialization signal to one first set electrode of respective display elements, the selection signal following such initialization signal and the non-selection signal while said initialization signal and said selection signal are not supplied; supplying a desired signal to the corresponding second set electrode; applying a pulse which sets said electro-optical modulation substance to the saturated reverse response condition in accordance with the voltage difference between said desired signal and said initialization signal; applying to said display elements a pulse group which includes display control pulses of

such duration and electric field intensity as to set the electro-optical modulation substance to the desired response condition with a voltage difference between said desired signal and said selection signal such as not to permit, after application of such display control pulse, the existence of a pulse which would change said response condition of said electro-optical modulation substance, said pulse group being composed of pulses which are of substantially the same waveform and of the same number but of different polarities; and applying at said display elements AC pulses to hold said electro-optical modulation substance to the said desired response condition in accordance with the voltage difference between said desired signal and said non-selection signal.

9. A method as claimed in claim 8 and which includes controlling the effective voltage value of said display control pulse in accordance with desired intermediate tone in or gradation of the display and controlling the waveform of said desired signal so that the effective voltage value of voltage of a pulse of substantially the same waveform but opposite polarity to that of said display control pulse in said pulse group is made equal to that of said display control pulse.

10. A method as claimed in claim 6 and which includes superimposing on the AC pulses which hold said electro-optical modulation substance in the said desired response condition, AC pulses of a higher frequency than said display control pulse.

11. A method as claimed in claim 10 and which includes controlling the voltage or the pulse duration of said display control pulse in accordance with desired intermediate tone in or gradation of the display and also controlling the waveform of said desired signal so that voltage and pulse duration of a pulse of reverse polarity but of substantially the same waveform as said display control pulse in said pulse group is made equal to that of said display control pulse.

12. A method as claimed in claim 6 or 8 and which includes superimposing on the AC pulses which hold said electro-optical modulation substance in the said desired response condition AC pulses of a higher frequency than said display control pulse.

13. A method as claimed in claim 12 and which includes controlling the voltage or the pulse duration of said display control pulse in accordance with a desired intermediate tone in or gradation of the display and also controlling the waveform of said desired signal so that the voltage and pulse duration of a pulse of reverse polarity but of substantially the same waveform as said display control pulse in said pulse group are made equal to that of said display control pulse.

14. A display apparatus including a display device of the kind referred to and means for generating waveforms for driving said device by a method as claimed in any of the preceding claims.

15. Apparatus as claimed in claim 14 wherein the electro-optical substance in said device is a ferro-electric liquid crystal and the waveform generating means includes means for generating waveforms for driving said device by a method as claimed in any of claims 10, 11, 12, or 13 and in which the superimposed high frequency is a frequency in a range in which the liquid crystal exhibits negative dielectric anisotropy.

16. Methods of driving display devices substantially as herein set forth and apparatus for carrying those methods into effect.

17. A method for driving an electro-optical display device, in an electro-optical display device consisting of display elements where an electro-optical modulation substance having different response conditions in accordance with the direction of applying the electric fields is provided between two electrodes, comprising the steps for;

supplying sequentially the selection signal to the one electrode of respective display elements, while non-selection signal when such selection signal is not supplied,

supplying the desired signal to the other electrode,

supplying to said display elements the pulse group which includes display control pulses having the duration and electric field for setting said electro-optical modulation substance to the desired response condition with a voltage difference between such desired signal and said selection signal, does not allow, after application of such display control pulse, existence of pulse which changes said response condition of said electro-optical modulation substance, and also includes the pulses having the same waveform and numbers in different polarities, and

applying to said display elements the AC pulses which hold said electro-optical modulation substance to said desired response condition in accordance with voltage difference between said desired signal and said non-selection signal.

18. A method for driving an electro-optical display device, in an electro-optical display device consisting of display elements where an electro optical modulation substance having different response conditions in accordance with the direction of applying the electric fields is provided between two electrodes, comprising the steps for;

supplying sequentially the selection signal to the one electrode of respective display elements, while non-selection signal when such selection signal is not supplied,

supplying the desired signal to the other electrode,

applying to said display elements the pulse group which includes display control pulses having the duration and electric field for set-

ting said electro-optical modulation substance to the desired response condition with a voltage difference between such desired signal and said selection signal, does not allow, after application of such display control pulse, existence of pulse which changes said response condition of said electro-optical modulation substance, and also includes the pulses having the same waveform and numbers in different polarities, and

applying to said display elements the AC pulses which hold said electro-optical modulation substance to said desired response condition in accordance with voltage difference between said desired signal and said non-selection signal, and

controlling an effective value of voltage of said display control pulse in accordance with the gradation of display and controlling waveform of said desired signal so that the effective value of voltage of pulse having the same waveform and polarity opposed to that of said display control pulse in said pulse group becomes equal to that of said display control pulse.

19. A method for driving an electro-optical display device, in an electro-optical display device consisting of display elements where an electro-optical modulation substance having different response conditions in accordance with the direction of applying the electric fields is provided between two electrodes, comprising the steps for;

supplying sequentially display initialization signal to the one electrode of respective display elements, the selection signal following such initialization signal and the non-selection signal while said initialization signal and said selection signal are not supplied,

supplying the desired signal to the other electrode,

applying a pulse which sets said electro-optical modulation substance to the saturated reverse response condition in accordance with voltage difference between such desired signal and said initialization signal,

applying to said display elements the pulse group which includes display control pulses having the duration and electric field for setting said electro-optical modulation substance to the desired response condition with a voltage difference between such desired signal and said selection signal, does not allow, after application of such display control pulse, existence of pulse which changes said response condition of said electro-optical modulation substance, and also includes the pulses having the same waveform and numbers in different polarities, and

applying to said display elements the AC pulses which hold said electro-optical modulation substance to said desired response condition in accordance with voltage difference between said desired signal and said non-selection signal.

20. A method for driving an electro-optical display device, in an electro-optical display device consisting of display elements where an electro-optical modulation substance having different response conditions in accordance with the direction of applying the electric fields is provided between two electrodes, comprising the steps for;

supplying sequentially display initialization signal to the one electrode of respective display elements, the selection signal following such initialization signal and the non-selection signal while said initialization signal and said selection signal are not supplied,

supplying the desired signal to the other electrode,

applying a pulse which sets said electro-optical modulation substance to the saturated reverse response condition in accordance with voltage difference between such desired signal and said initialization signal,

applying to said display elements the pulse group which includes display control pulses having the duration and electric field for setting said electro-optical modulation substance to the desired response condition with a voltage difference between such desired signal and said selection signal, does not allow, after application of such display control pulse, existence of pulse which changes said response condition of said electro-optical modulation substance, and also includes the pulses having the same waveform and numbers in different polarities,

applying to said display elements the AC pulses which hold said electro-optical modulation substance to said desired response condition in accordance with voltage difference between said desired signal and said non-selection signal, and

controlling an effective value of voltage of said display control pulse in accordance with the gradation of display and controlling waveform of said desired signal so that the effective value of voltage of pulse having the same waveform and polarity opposed to that of said display control pulse in said pulse group becomes equal to that of said display control pulse.

21. A method for driving an electro-optical display device, in an electro-optical display device consisting of display elements where an electro-optical modulation substance having different response conditions in accordance with the direction of applying the electric fields is provided between two electrodes, comprising the steps for;

supplying sequentially the selection signal to the one electrode of respective display elements, while non-selection signal when such selection signal is not supplied,

supplying the desired signal to the other electrode,

applying to said display elements the pulse group which includes display control pulses

having the duration and electric field for setting said electro-optical modulation substance to the desired response condition with a voltage difference between such desired signal and said selection signal, does not allow, after application of such display control pulse, existence of pulse which changes said response condition of said electro-optical modulation substance, and also includes the pulses having the same waveform and numbers in different polarities, and

applying the AC pulse, to which the AC pulse having the frequency higher than said display control pulse is superposed, which holds said electro-optical modulation substance to said desired response condition in accordance with voltage difference between said desired signal and said non-selection signal, to said display elements.

22. A method for driving an electro-optical display device, in an electro-optical display device consisting of display elements where an electro-optical modulation substance having different response conditions in accordance with the direction of applying the electric fields is provided between two electrodes, comprising the steps for;

supplying sequentially the selection signal to the one electrode of respective display elements, while non-selection signal when such selection signal is not supplied,

supplying the desired signal to the other electrode,

applying to said display elements the pulse group which includes display control pulses having the duration and electric field for setting said electro-optical modulation substance to the desired response condition with a voltage difference between such desired signal and said selection signal, does not allow, after application of such display control pulse, existence of pulse which changes said response condition of said electro-optical modulation substance, and also includes the pulses having the same waveform and numbers in different polarities,

applying the AC pulse, to which the AC pulse having the frequency higher than said display control pulse is superposed, which holds said electro-optical modulation substance to said desired response condition in accordance with voltage difference between said desired signal and said non-selection signal, to said display elements, and

controlling voltage or pulse duration of said display control pulse in accordance with the gradation of display and also controlling waveform of said desired signal so that voltage and duration of pulse which has reverse polarity and the same waveform to said display control pulse in said pulse group become equal to that of said display control pulse.

23. A method for driving an electro-optical display device, in an electro-optical display device consisting of display elements where an electro-optical modulation substance having different response conditions in accordance with the direction of applying the electric fields is provided between two electrodes, comprising the steps for;

supplying sequentially display initialization signal to the one electrode of respective display elements, the selection signal following such initialization signal and the non-selection signal while said initialization signal and said selection signal are not supplied,

supplying the desired signal to the other electrode,

applying a pulse which sets said electro-optical modulation substance to the saturated reverse response condition in accordance with voltage difference between such desired signal and said initialization signal,

applying to said display elements the pulse group which includes display control pulses having the duration and electric field for setting said electro-optical modulation substance to the desired response condition with a voltage difference between such desired signal and said selection signal, does not allow, after application of such display control pulse, existence of pulse which changes said response condition of said electro-optical modulation substance, and also includes the pulses having the same waveform and numbers in different polarities, and

applying the AC pulse, to which the AC pulse having the frequency higher than said display control pulse is superposed, which holds said electro-optical modulation substance to said desired response condition in accordance with voltage difference between said desired signal and said non-selection signal, to said display elements.

24. A method for driving an electro-optical display device, in an electro-optical display device consisting of display elements where an electro-optical modulation substance having different response conditions in accordance with the direction of applying the electric fields is provided between two electrodes, comprising the steps for;

supplying sequentially display initialization signal to the one electrode of respective display elements, the selection signal following such initialization signal and the non-selection signal while said initialization signal and said selection signal are not supplied,

supplying the desired signal to the other electrode,

applying a pulse which sets said electro-optical modulation substance to the saturated reverse response condition in accordance with voltage difference between such desired signal and said initialization signal,

applying to said display elements the pulse group which includes display control pulses having the duration and electric field for setting said electro-optical modulation substance to the desired response condition with a vol-

tage difference between such desired signal and said selection signal, does not allow, after application of such display control pulse, existence of pulse which change said response condition of said electro-optical modulation substance, and also includes the pulses having the same waveform and numbers in different polarities, and

applying the AC pulse, to which the AC pulse having the frequency higher than said display control pulse is superposed, which holds said electro-optical modulation substance to said desired response condition in accordance with voltage difference between said desired signal and said non-selection signal, to said display elements, and

controlling voltage or pulse duration of said display control pulse in accordance with the gradation of display and also controlling waveform of said desired signal so that voltage and duration of pulse which has reverse polarity and the same waveform to said display control pulse in said pulse group become equal to that of said display control pulse.

25. A method for driving an electro-optical display device according to claims (1), (2), (3) and (4), wherein said electro-optical modulation substance is a ferroelectric liquid crystal which shows negative dielectric anisotropy in a high frequency region superposed to the AC pulse which holds said response condition.

26. Any novel integer or step, or combination of integers or steps, hereinbefore described and/or shown in the accompanying drawings irrespective of whether the present claim is within the scope of, or relates to the same or a different invention from that of, the preceding claims.

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1986, 4235.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.